High-Resolution Rutherford Backscattering Analysis of Nanoscale Thin Films

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Rutherford backscattering spectroscopy (RBS) has been an important analytic method for determination of the depth distribution of elemental concentrations in materials. The depth resolution of RBS is typically limited by the energy resolution of ion detectors. In this work we demonstrate the use of a compact magnetic spectrometer as the ion energy detector for high-resolution RBS analysis. The magnetic spectrometer offers several advantages: (1) a high energy resolution $\Delta E/E \sim 1/2000$; (2) a large bending power for MeV ions; and (3) a particular configuration allowing for true 180° RBS analysis. By combining this magnetic spectrometer with the grazing angle geometry, we have achieved a depth resolution better than 5 Å for RBS analysis of concentration distributions in elemental (e.g., Ta) and compound (e.g. HfO_2) thin films using 2 MeV helium ions. These experimental results suggest that high-resolution characterization of nanoscale thin films can be realized using MeV ions in conjunction with such magnetic spectrometers. The advantages of our method for nanoscale thin film analysis over medium energy ion scattering (MEIS) will be discussed.